



SMD Snow Mobility

Kalind Carpenter

Robotics Engineer, Robotic Vehicles and Manipulators Group
Jet Propulsion Laboratory, California Institute of Technology



Objectives



- Enabling mobility on unconsolidated powder snow and slush
 - Highly compliant wheels to maximize contact patch of wheels
 - Treads to provide thrust in unconsolidated snow and traction on packed snow and ice
- Instrumentation
 - Roving GPS for mapping glacial surface topography
 - Tethered results achieved, untethered soon





Overarching Goals

What:

- Human portable snow mobility platform
- Modular instrument interface
- Impact tolerant low cost design

Why:

- Increase measurements in field, human portable “Roomba” sensor
- Large area coverage, many deployed from helicopters
- Reduced cost ice sheet science measurements, small “printed” robot

Where:

- Greenland ice sheets
- Antarctica ice sheets





State of the Art Comparisons

Platform	PUFFER	GROVER	Cool Robot	SnoBot 2
Mass	0.25 kg	363 kg	61 kg	14.6 kg
Speed	1 km/h (1.8 km/h Straight)	2 km/h	2.88 km/h	3.6 km/h
Ground Pressure	1.16 kPa	*	15 kpa	1.45 kPa
Slope	32 degree	*	30 degree	*



PUFFER



GROVER



Cool Robot



SnoBot 1 & 2





Preliminary Tests



Lab and field tests of PUFFER in unconsolidated snow.





Preliminary Tests



Initial Testing with Compliant Wheels

Location: Colorado

Date: November 2016

© 2017 California Institute of Technology. Government sponsorship acknowledged.





Antarctica “Stow Away”



Antarctica “Stow-Away” Experiment

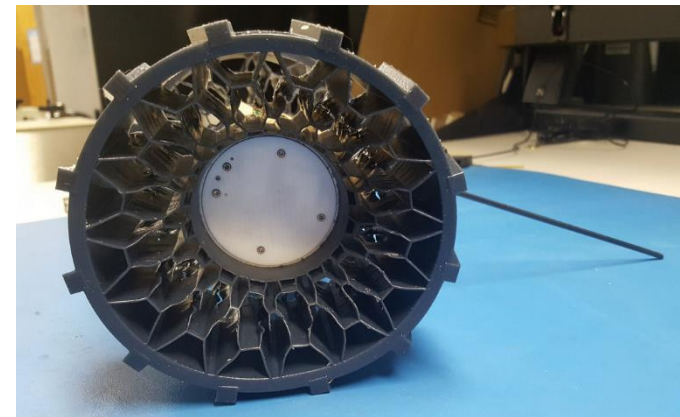
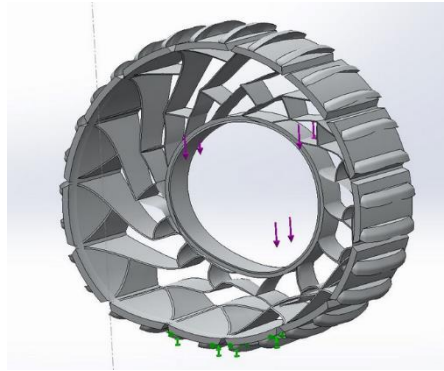
Location: Mt. Erebus, Antarctica

Date: December 2016





Custom Compliant Wheels





Preliminary Tests



Compliant Wheel Field Testing

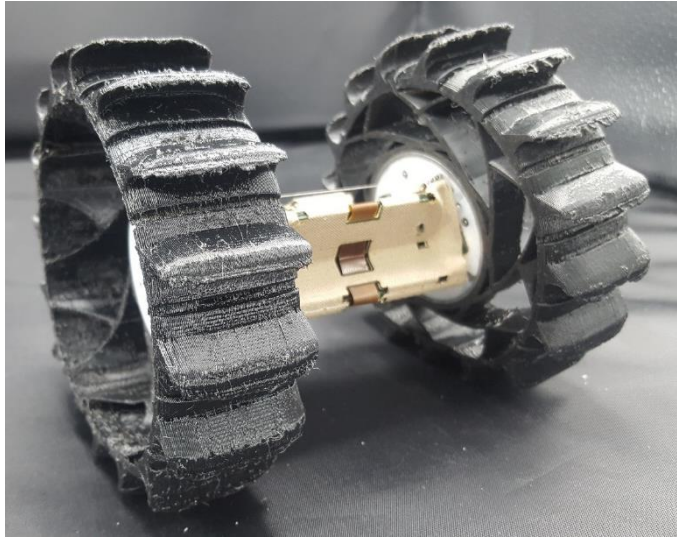
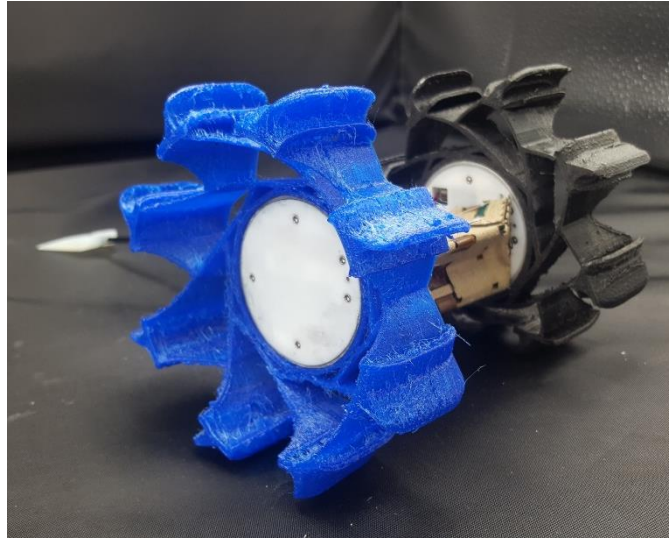
Location: Big Bear, California

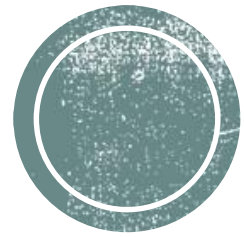
Date: December 2016





Cold Tolerant Polymer





Field Test 1/23

Quantitative Field Testing

Location: Waterman Mountain, California

Date: January 2017



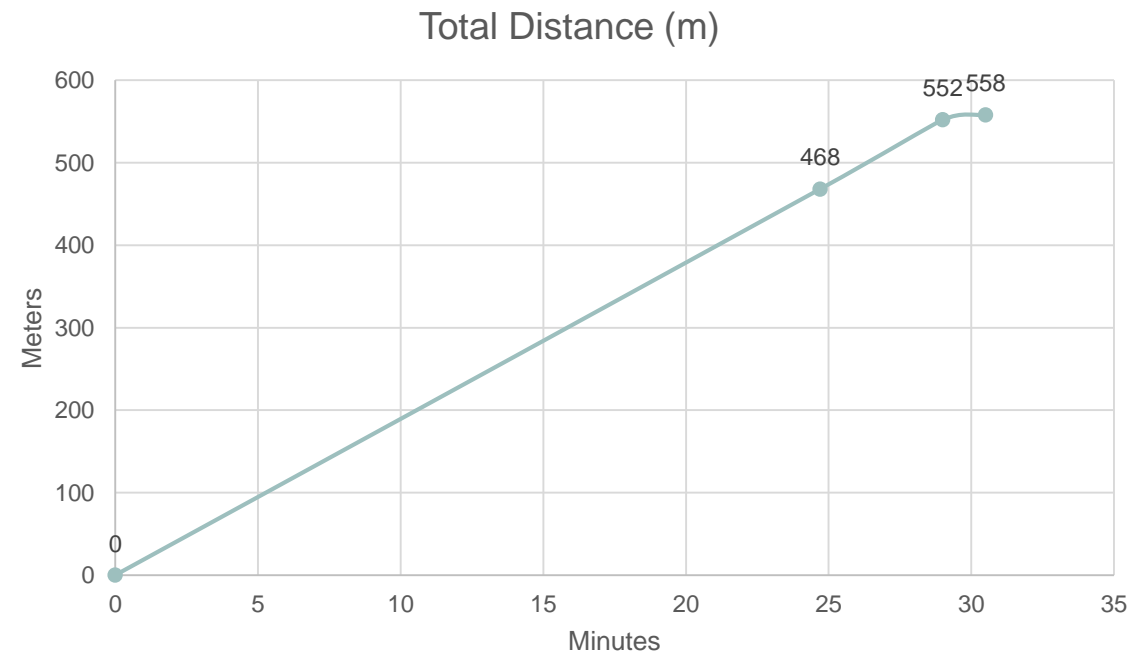
Endurance Test





Endurance

- 180 mAh 2s Battery





Slope Tests 23 Degree Unconsolidated Snow





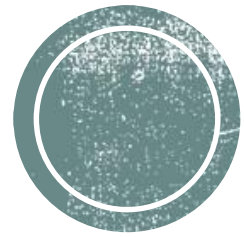
Slope Tests 32 Degree Slope





Slush Mobility



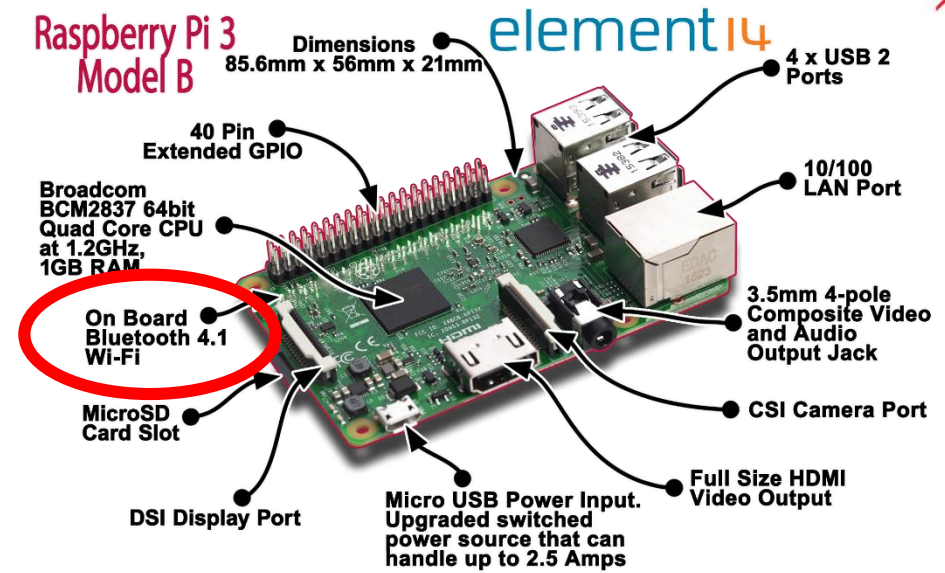


GPS Logging

The instrument payload for this effort is a RTK GPS logging system, which will be used to build topographic maps while roving over large snow and ice covered areas.

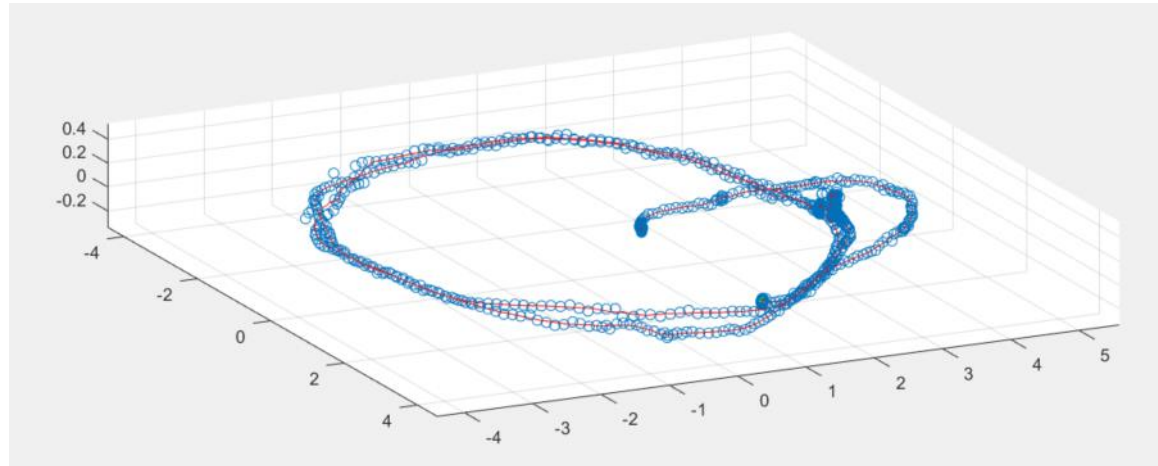
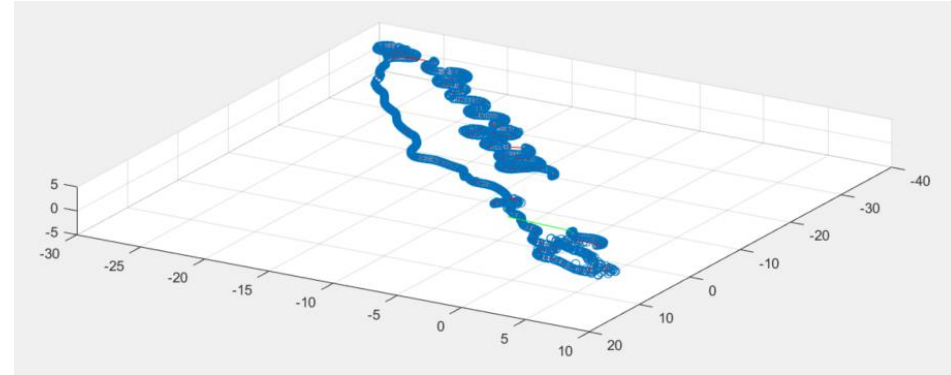
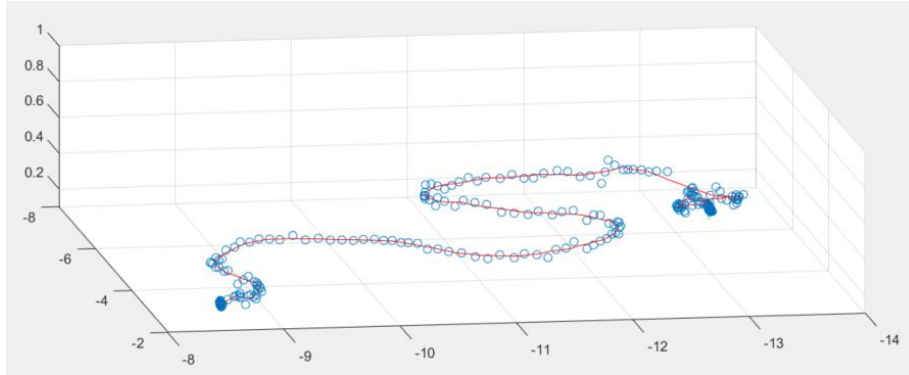


GPS Logging





Tethered GPS Logging Results





Conclusion and Future Work

- Feasibility of PUFFER mobility on snow demonstrated!
- Slopes up to 32 degrees! Demonstrated
- Tether-less GPS data logging near completion
- Next targets:
 - GPS Logging components to snow mobility platform
 - Full mobility endurance
 - More challenging slopes up to 30 + degrees unconsolidated snow

